

Feasibility of sustainable water management in prospect of the development of oil and gas industry in the Kharkiv and Donetsk regions of Ukraine by 2040

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Zrównoważone zarządzanie zasobami wodnymi na Ukrainie w obwodach Charkowskim i Donieckim w kontekście rozwoju przemysłu naftowego i gazowniczego regionu do 2040 r. Prz. Geol., 64: 925–928.

Abstract. Intensyfikacja produkcji gazu jest jednym z najważniejszych wyzwań, jakie stoją przed przemysłem naftowym. Zasoby niektórych złóż gazu są niewielkie, ale w sumie dają potężną ilość i będą wymagać specjalnych technologii wydobywczych. Wielkoskalowa przemysłowa produkcja gazu jest prowadzona z użyciem szczelinowania hydraulicznego. Praca prezentuje wyniki projektu badawczego dotyczącego optymalizacji zarządzania zasobami wodnymi w kontekście rozwoju przemysłu naftowego i gazowniczego w obwodach Charkowskim i Donieckim na Ukrainie oraz

minimalizacji zagrożeń wobec środowiska naturalnego. Głównymi rozpatrywanymi w badaniach zagadnieniami było rozpoznanie, analiza i systematyzowanie faktów na temat obszarów perspektywicznych, w celu dalszych interpretacji w odniesieniu do warunków hydrogeologicznych i potencjału zasobów wodnych, w związku z prognozowaną wielkością wydobywania z odwiertów w obwodach Charkowskim i Donieckim. Szczególną wagę przywiązywano do obliczeń zasobów wodnych niezbędnych dla szczelinowania hydraulicznego, z uwzględnieniem wszystkich możliwych kosztów. Jako wynik tego projektu, zaproponowano wybór źródeł zasobów wodnych do ewentualnego zabezpieczenia koniecznych ilości wód dla prac wiertniczych i realizacji szczelinowania hydraulicznego.

Słowa kluczowe: zasoby wodne, niekonwencjonalne złoża gazu, prognozowanie, szczelinowanie hydrauliczne, warunki hydrogeologiczne

Abstract. Intensification of gas production is one of the most important challenges of oil and gas industry. Reserves of some gas collectors are small, but they are huge in the aggregate and will require special production technologies. Large-scale industrial gas production is performed using the technology of hydraulic fracturing. The study showed the results of research project as concerns the optimization of water management in the context of development of oil and gas industry in the Kharkiv and Donetsk regions of Ukraine and minimization of environmental risks. The research includes the study, analysis and systematization of evidence of prospective areas for further interpretation in relation to the hydrogeological conditions and potential of water resources in connection with the forecast volumes of the output of exploration and production wells in the Kharkiv and Donetsk regions. The special attention was spared to the calculations of necessary water resources for hydraulic fracturing including all possible charges. Accompanying with this, as a result of this project, a choice has been done about water resources for the possibility of providing necessary water volumes for projected drilling works and implementation of “fracking” operations.

Keywords: water resources, unconventional gas, forecasting, hydraulic fracturing, hydrogeological conditions

Extremely challenging fuel and energy balance of Ukraine, and a consistent trend of drastic increase in the prices of oil products and coal stipulates the reason to revive researches of deposits in Ukraine, which are located in areas with developed infrastructure and are of interest for further research, development and exploitation. In this concern, development and exploitation of sources of unconventional energy deposits is associated with using a significant amount of water resources.

Natural gas recovery from unconventional sources is more complicated and more expensive than the conventional way of natural gas recovery. Technological improvements and advances have made gas recovery from unconventional sources feasible over last years. Besides, the combination of horizontal drilling and hydraulic fracturing has significantly increased the capacity of gas wells. These innovative methods, however, have raised concerns in terms of negative environmental and social consequences of such practice particularly connected with impact on water resour-

ces. Exploitation and industrial development of such deposits of tight gas collectors is done by means of hydraulic fracturing technology (Usachev, 1986).

Hydraulic fracturing is a standard practice applied for natural gas recovery from unconventional sources, including coal beds of shale and tight sandstones. This practice is increasingly applied for conventional sources, improving the capacity of extraction wells. At the moment, this process requires provision of water resources in respective amounts and types of applied chemical substances as well as the quality and amount of discharged water that is generated for repeated multiple application of the fracturing fluid.

There is a set of factors concerned with this technology, which potentially influence the environment, such as: risk of groundwater pollution caused by overflow or water entrainment, indrawal waters from other hydraulically connected water bearing layers at the moment of water withdrawal or proppant injection; improper managing and regulating of discharged waters as a result of completion of

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several technological cycles of hydraulic fracturing; potential migration of gases and hydraulic chemical substances of hydraulic fracturing onto surface or into underlying or overlying water bearing layers. There is a certain risk of impact of this technology on the environment and particularly on underground elements of the hydrosphere. However, the detailed study, analysis and justification of projected works at prospective plots of gas deposits will provide opportunity to minimize the impact of technologies on the environment.

First of all, it is necessary to describe and characterize hydrologic conditions of the region and later to indicate each of the deposits and summarize data. Such feasibility is based on a forecast of planned drilling works at exploration and prospecting wells and application of hydraulic fracturing. Revising the deposit situated in a certain area, studying adjacent territories and considering the potential effect of border conditions of the deposit are deemed to be obligatory. Hydrologic conditions of the plots include climate conditions of the territory, taking into account features of the geological structure and tectonic character of the region. Each of these parameters affects the general geological environment during and after exploitation of energy resources. Subsequently, evaluation of resource potential of the territory will be executed, and qualitative and quantitative characteristics of the water-bearing system and the degree of water resources renovation will be determined, taking into account the local water balance.

The research focuses on the Kharkiv and Donetsk regions of Ukraine. These two regions and its suburbs are characterized by high gas content of coal layers and the adjacent rocks, extensive development of porous reservoir rocks and the presence of a decompaction zone.

Research methods involve general approaches to data collection and processing, in particular systematization and analysis of evidence of prospective areas for further interpretation and forecast.

WATER MANAGEMENT IN PROSPECT OF THE DEVELOPMENT OF OIL AND GAS INDUSTRY IN THE KHARKIV AND DONETSK REGIONS – CALCULATION, FEASIBILITY AND CONCLUSIONS

Kharkiv region. Depending on geographical location, the climate in the Kharkiv region is moderate-continental with cold winters and hot summers. The hydrologic system of the Kharkiv region includes such rivers as Severski Donets, Oskil, Uda, Lopan, Kharkiv and others. The main source of rivers' recharge is rainfall. Regionally, this area is a part of the Dneprovsk-Donetsk artesian basin. In respect of

the geological structure there are 12 water-bearing layers and complexes in this area (Repina, 2007).

We are analyzed the dynamics of water use in the Kharkiv region according to latest data obtained from an ecological certificate of the Kharkiv region (Table 1). Surface waters withdrawal is the most intensive. It increases annually but does not exceed 400 millions cubic meters per year.

The dynamics of changes in natural surface water withdrawal over the period from 2003 to 2010 shows a decrease, and since 2010 it demonstrates an increasing trend. Seasonal fluctuations are rather normal. It is explained by the fact that surface waters are hydrologically connected as a whole ecological system. It is also stipulated by their connection with artesian and ground waters in the complex.

According to predicted calculations of required water resource volumes in the Kharkiv region for the purpose of oil and gas industry development in this region for the period of 2016–2040 there are three scenarios: pessimistic scenario – 20–30 thousand cubic metres, basic scenario – 20–30 thousand cubic metres, and optimistic scenario is up to 100 thousand cubic metres or even more.

Water withdrawal from natural sources in the Kharkiv region since 2004 was significantly decreasing and this trend maintained until 2013. In this regard, the trend line shows that further decrease of groundwater withdrawal will be observed in this region by 2040. Main sources of water in the Kharkiv region are surface waters. They comprise the major part in water withdrawal from natural sources.

At certain plots, it is possible to make more detailed evaluation of water volumes that will be recovered. The balance method can be applied for this purpose. Balance method for evaluation of exploitable reserves will help to determine the potential of constituents of water withdrawal balance mainly of natural reserves and resources and, if there are certain hydrologic conditions, then other resources are attracted (Plotnikov, 1973). Similar evaluation and analysis should be executed for the whole deposit in order to identify exploitable reserves locally, and to determine potential exploitable possibilities in general. It will provide opportunity to compare them with required water resources. Based on achieved results.

According to predicted data, the required amount of water resources to be used in the Kharkiv region will be based on the pessimistic and base scenarios, not exceeding 20–30 thousand cubic metres. Based on the optimistic scenario this amount does not exceed 100 thousand cubic metres.

However, annual surface and ground water withdrawal comprises 350 million cubic metres (Ecological passport..., 2014). In this concern water resources requirements including all three scenarios are not critical. Taking into account hydrogeological conditions in the Kharkiv region, the main

Table 1. Dynamics of water withdrawal from natural sources in 2003–2013 in the Kharkiv region

Tab. 1. Dynamika pobierania wody z naturalnych źródeł w latach 2003–2013 w obwodzie Charkowskim

Years <i>Lata</i>	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Total [million cubic metres] <i>Ogółem [mln m³]</i>	415.6	408.1	357.4	350.2	348.5	362.7	331.1	337.4	384.8	375.9	388.3
Surface water [million cubic metres] <i>Wody powierzchniowe [mln m³]</i>	345.5	341.3	293.3	291.8	293.8	309.7	284.5	291.4	341.4	335.1	347.6
Groundwater [million cubic metres] <i>Wody podziemne [mln m³]</i>	70.08	66.83	64.1	58.37	54.7	53	46.6	46	43.4	40.8	40.7

Table 2. Dynamics of water withdrawal from natural sources in 2003–2012 in the Donetsk region
Tab. 2. Dynamika pobierania wody z naturalnych źródeł w latach 2003–2012 w obwodzie Donieckim

Years <i>Lata</i>	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Total [million cubic metres] <i>Ogółem [mln m³]</i>	2204	2291	2223	2277	2364	2164	1958	2007	2142	2093
Surface water [million cubic metres] <i>Wody powierzchniowe [mln m³]</i>	1809	1798	1734	1795	1900	1772	1588	1687	1765	1715
Groundwater [million cubic metres] <i>Wody podziemne [mln m³]</i>	396	492.8	489.3	481.2	464.3	391.9	370.4	320	377	377.9

source of water resources is provided by surface water and the water is supplied in necessary volume. The quality of the aquifer system is satisfactory.

Thus, the quality and regime of water resources in the aquifer system in the Kharkiv region is satisfactory, and can be used for water supply during future drilling works and technological processes of hydraulic fracturing.

Donetsk region. Groundwater province of Donetsk folded area comprises the Donetsk region that is situated in eastern Ukraine. This is an area of hydrocarbonate-chloride and chloride-sulphate waters with different contents of cations, and increased and high mineralization of iodine-bromine waters in the Dneprovsk artesian basin and Donbas. It is characterized by development of small artesian basins and diverse chemical composition of groundwaters in Triassic, Jurassic and Cretaceous deposits. Main aquifers within the Donetsk basin are related to Jurassic, Triassic, Permian and coal deposits (Hydrogeology ..., 1977).

The Donetsk region should be supplied with water resources for the purposes of exploitation of energy source deposits. It is a very important issue and requires recommendations.

Analyzing the condition of the underground hydrosphere in the Donetsk region, we can make a conclusion that this area has enough aquifers capable to support long-term water supply in the region. Among the water resources ready for use in the Donetsk region is mine waters.

Water withdrawal from natural sources in the Donetsk region has unstable character, but the decrease of water resources withdrawal is observed annually (Table 2). According to hydrogeological characteristics of the region, this area provides water mainly from surface waters and partly from groundwaters. Analysis of changes in the dynamics of surface waters withdrawal shows a gradual stabilization and decrease of water withdrawal since 2007, which is 1700 million cubic metres in average. Similar situation is observed concerning groundwaters withdrawal in the Donetsk region, but withdrawal decrease started in 2008. In 2010, the amount was 320 million cubic metres totally. Such a fixed parameter indicate partial changes in filtration parameters of the aquifers or an effect of unstable geological environment of the area under influence of technogenic factors.

Predicted water volumes for drilling exploration and prospecting wells and application of hydraulic fracturing, based on pessimistic, basic and optimistic scenarios in the Donetsk region during 2016–2040 years, are not more than 10 thousand cubic metres and approximately up to 70 thousand cubic metres for the latter two, respectively.

At the same time, the dynamics of groundwater withdrawal in the Donetsk region shows a general decrease of water

withdrawal from surface and natural groundwater sources, and is supposed to continue until 2040 in exploitation.

Total water supply with water resources is provided by surface waters and partly by groundwater. The Donetsk region includes different aquifers with different mineralization mostly due to availability of high volumes of mine waters in the area. As compared to predicted volumes of water required for the cycle of technological works withdrawal of surface and ground waters can satisfy the needs without serious consequences for hydrosphere. All water inputs for the Donetsk region are satisfactory. Besides, mine waters might be used as additional sources of water resources. However first of all, mine waters should meet the water quality requirements in order to use them for drilling and hydraulic fracturing.

The quality of surface and groundwaters in the Donetsk region is satisfactory; there is only one issue concerned with availability of mineralized waters. Recharge of withdrawn water resources is partial and can be evaluated for certain deposits. In general, the water balance is restored seasonally depending on indicators of hydrologic cycle, climatic conditions and exploitation of the series of aquifers in the region.

CONCLUSIONS

Volumes of unconventional power sources give a reason to expect an active exploration and extraction in Ukraine in the next decade. It is required to prepare an algorithm of actions for the development of many oil and gas basins: from exploration works to the production of hydrocarbons. Different climate zones, landscapes, seasons, transportation of water resources and a variety of factors impact the legislation of individual states and the price policy of water use. The majority of mining companies have adapted to the new strict conditions. We have to use their experience to analyze possible difficulties in the future of oil and gas industry in Ukraine. The team of “Petroply Research and Consulting” company in cooperation with foreign experts has successfully completed the project of sustainable water management in prospect of the development of oil and gas industry in the Kharkiv and Donetsk regions of Ukraine by 2040. The results of the researches include an assessment of available fresh water for the development and exploration of wells, and using of underground sources of fresh water by other water users in the region.

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